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Conducting pro-social research:
cognitive diversity, research excellence and awareness of the social impact of research

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Background topics and main motivation

Scientific vs. commercial incentives

Antecedents of knowledge and technology transfer: not just entrepreneurship

Understand what drives scientists to conduct research with a strong awareness of social relevance and impact: 'Pro-social research'

Individual heterogeneity in terms of skill-sets

Literature background

- The non-trivial transit from academic research to engagement in technology transfer activities

  • Norms / Processes / Outputs: differ between academic and business environments (Jain et al., 2009; Tartari & Breschi, 2010; Philpott et al., 2011)

- Understanding how to manage this transit has led to a focus on scientists' individual characteristics

  • Adoption of a *hybrid role identity*: a growing self-awareness about the importance of commercial opportunities as part of a scientist role (Jain et al., 2009)

  • Formation of *positive expectations*: beliefs on expected 'academic' gains (e.g.. peer recognition) from commercial activities, that predict entrepreneurial intentions to entrepreneurship (Goethner et al, 2011)

  • Development of *entrepreneurial skills*: the importance of technical and managerial skills as predictors of entrepreneurial behaviour (Fini, et al., 2011)

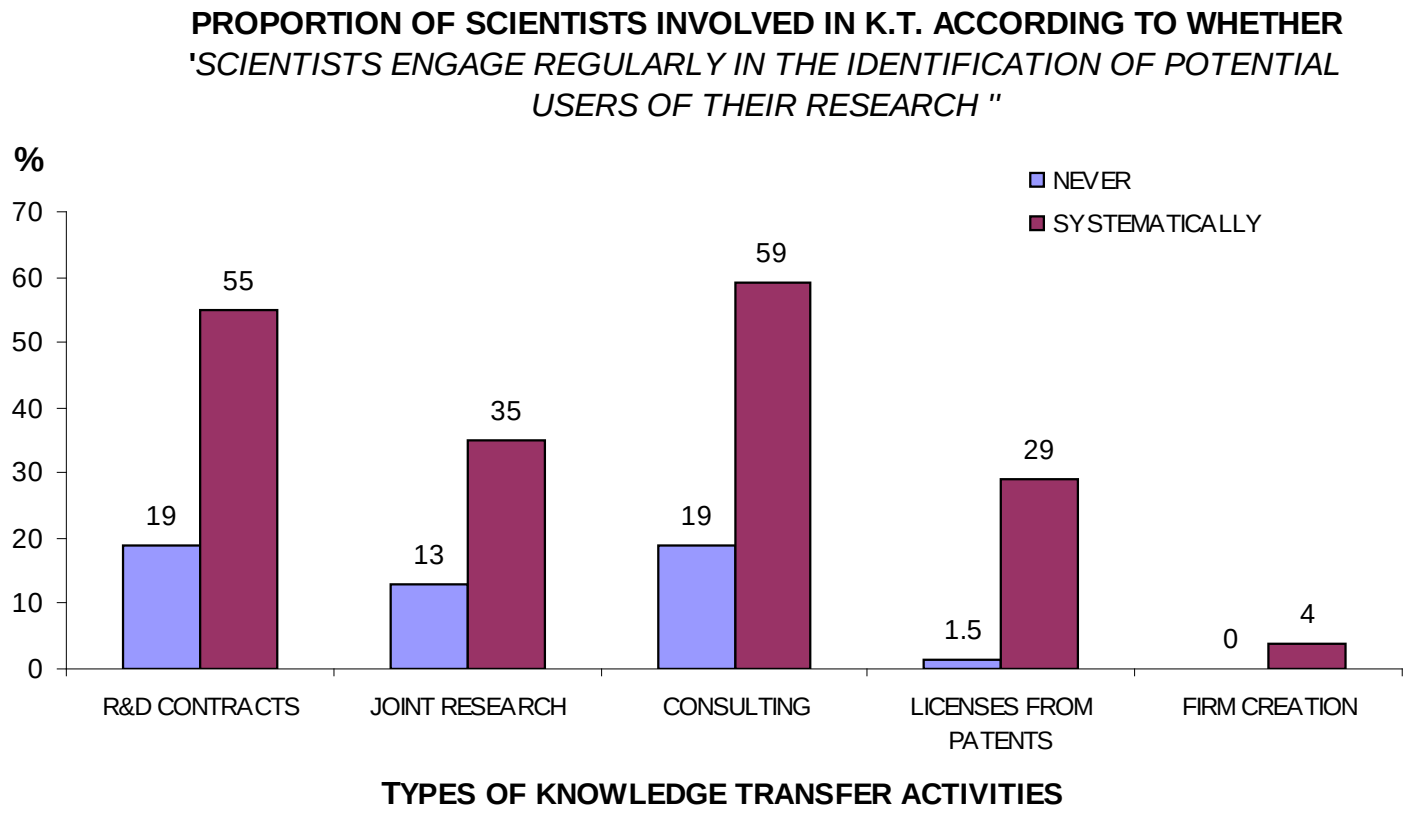
  • *Career trajectories* of scientists: the relationship between previous experience outside academia and scientific performance (Dietz & Bozeman, 2005)

Literature background (2)

- One recurrent "theme" in the literature is the importance attached to: the adoption of *attitudes* and *conducts* that place social relevance as a critical goal of research. Attitudes and conducts favourable to:
  - recognition of research results with a potential social impact (Shane & Venkataraman, 2000)
  - identification of the potential users' of research findings (Stokes, 1996; Gibbons et al., 1994)
  - delegation on intermediary agents to realise the social impact of research (Jain et al., 2011)

- We characterise these research *attitudes* and *conducts* as: *Pro-Social research*
  - As these research practices reflect 'a concern about positively affecting others' (Grant et al., 2007): "Perceived pro-social impact is defined as the judgement that one's actions are beneficial to other people"
  - Organisational Behaviour theory suggests that:
    - pro-social attitudes and conducts help increase interaction with the environment
    - at the same time, pro-social attitudes / conducts enhance motivation at work, as they contribute to experience work as more meaningful and strengthen a feeling of social worth (Grant et al., 2007)

Conducting *Pro-social research* may be strongly associated with the involvement in knowledge transfer activities



Literature background (3)

What type of *skills* are conducive to pro-social research behaviour among scientists with *little (or no)* experience in knowledge transfer?

- *Experience* matters: *frequent entrepreneurs master skills to enact K.T. activities*

Scientists who have engaged in knowledge transfer activities in the past are likely to be more willing and able to conduct pro-social research

– prior experience in entrepreneurship might help individuals to develop specific skills as "habitual entrepreneurs" (Hoye & Prices, 2009; Shane & Khurana, 2003)

– scientists with successful experience in KT may become more aware of the commercialization potential of their research results (Goethner, et al., 2012; Landry et al., 2006)

- *However, our contention is that Pro-Social research is likely to be a behavioural antecedent of involvement in K.T. among those scientist with no prior experience*

– We consider *Research Excellence* and *Cognitive diversity* as potential substitutes for *Experience*.

Literature background (3a)

1. Research excellence and pro-social research

• Scientists with outstanding research skills and scientific performance may exhibit higher visibility outside academia, exerting a *signalling effect* on potential users of their research (Landry et al., 2006; Perkmann et al., 2011)

• However, scientists may also be reluctant to pro-social research if they fear that it endangers their efforts to reach increasing recognition among peers (Stephan, 2010).

We expect that:

H1a: Research excellence is positively linked to conducting pro-social research;

H1b: This relationship may exhibit a U-shape if scientists are reluctant to pro-social research behaviour at intermediate levels of research excellence.

• The signalling effect may play a particularly strong role in driving pro-social research among those scientists with no (or little) prior experience in K.T., compared to those who are regularly engaged in K.T. Thus,

H2: Research excellence has a higher impact on pro-social research at lower levels of experience in knowledge transfer activities.

Literature background (3b)

2. Cognitive diversity and pro-social research

• Scientists with a broader expertise across fields of science (*interdisciplinary skills*) are likely to conduct *distant* search and develop gatekeeper roles, identifying new lines of inquiry and enhancing awareness of social relevance and commercial opportunities (Fleming et al., 2007; D'Este et al., 2012)

• Too broad cognitive breadth, however, may impose challenges to knowledge integration (Rafols & Meyer, 2010; Yegros, et al., 2011).

We expect that:

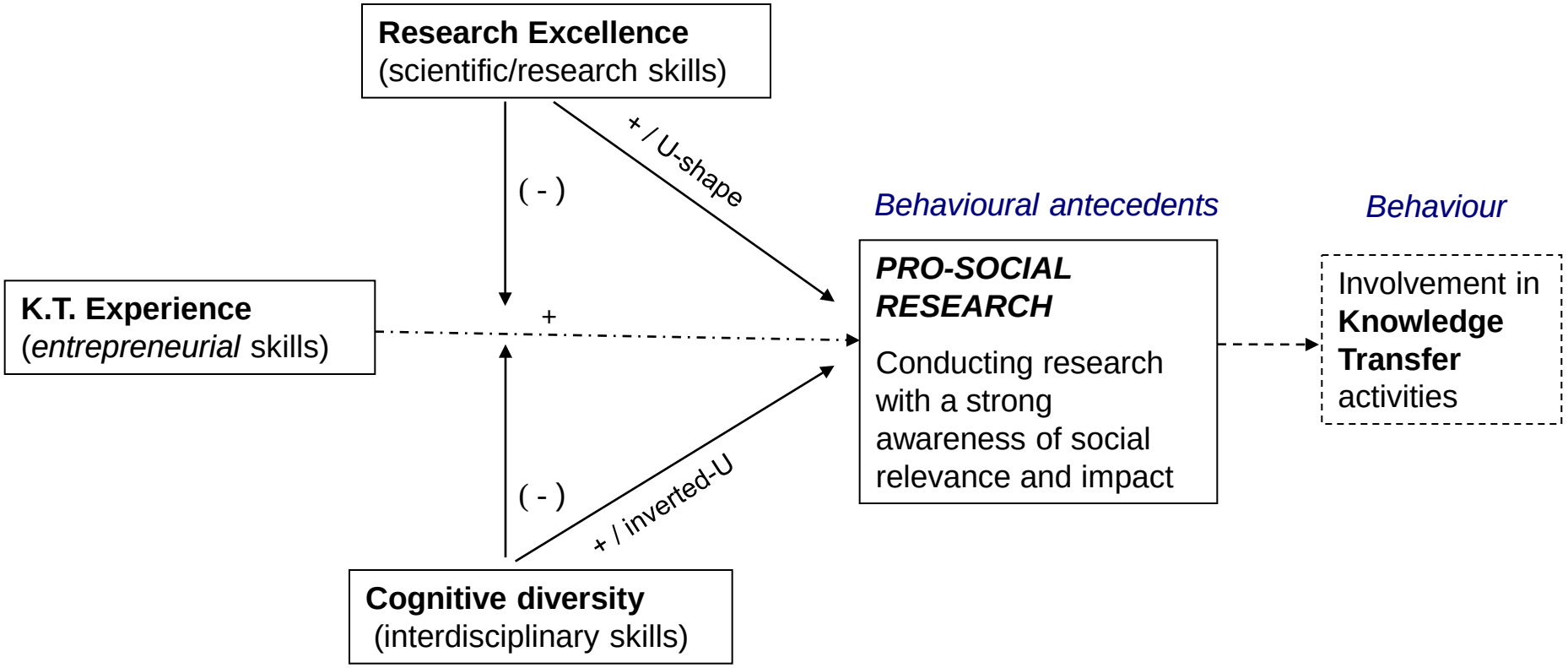
H3a: Cognitive diversity is positively linked to conducting pro-social research;

H3b: This relationship may exhibit an inverted U-shape if increasing levels of cognitive diversity have a decreasing impact on scientists' ability to conduct pro-social research.

• Cognitive diversity may play a particularly strong role in driving pro-social research among those scientists with no (or little) prior experience in K.T., compared to those who are regularly engaged in K.T. Thus,

H4: Cognitive diversity has a higher impact on pro-social research at lower levels of experience in knowledge transfer activities.

PROPOSED FRAMEWORK: what type of skills are necessary to conduct pro-social research?



DATA SOURCES AND METHOD

- **SURVEY DATA**:
  - Data from a large scale survey to all researchers at the Spanish Council for Scientific Research (CSIC): the main PRO in Spain
  - Sample frame: the whole population of tenured scientists at CSIC: 3199 scientists
  - Using email addresses, scientists were invited to participate on an on-line survey. It was implemented between 7th April 2011 and 24th May 2011 (with two reminders).
  - Response rate: 40%; 1295 valid responses
  - The survey sample is representative in terms of age, gender, academic rank and scientific field relative to the target population

- **SECONDARY SOURCES OF INFROMATION**
  - Administrative sources of information for demographic data (i.e. gender, age, academic rank, scientific field and institute of affiliation)
  - Publications from Science Citation Index (SCI)
    - Number of publications and citations
    - Subject categories for field specialisation

MEASURES

DEPENDENT VARIABLE

PRO-SOCIAL RESEARCH:
Conducting research with a strong awareness of social relevance and impact

- We measured *PRO-SOCIAL* by averaging the responses to the following three items:

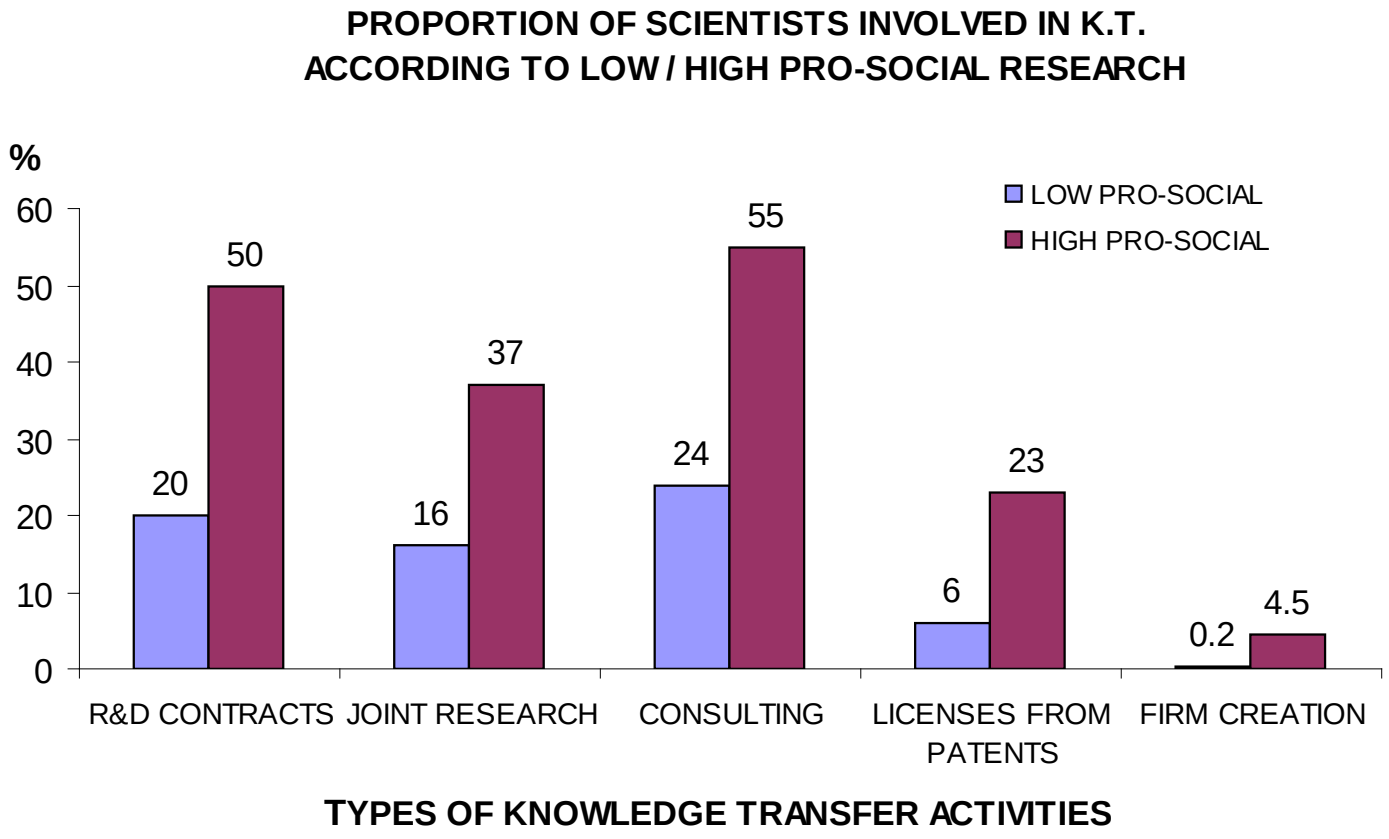
Survey Question: **Indicate the frequency you engage in each of the following activities when you conduct a research project?**				
	Never			Regularly
	1	2	3	4
Identify the potential results of your research that can benefit different types of users				
Identify the potential users (individuals or organizations) who could apply the results of your research				
Identify intermediaries (individuals, organizations or networks) in order to transfer the results of your research to potential users				

- Cronbach $\alpha = 0.80$

Proportion of scientists with *High* / *Low* Pro-Social scores, by field of science

Scientific fields	HIGH PRO-SOCIAL (highest quartile)	LOW PRO-SOCIAL (lowest quartile)	N. Obs.
Food Science & Technology	48%	15%	113
Social Science & Humanities	43%	32%	69
Agriculture Science & Technology	39%	22%	185
Physics Science & Technology	38%	35%	153
Technology for New **Materials**	32%	35%	158
Chemistry Science & Technology	32%	31%	173
Natural Resources	26%	36%	182
Biology & Biomedicine	17%	50%	186

The relationship between Pro-social research and involvement in knowledge transfer activities



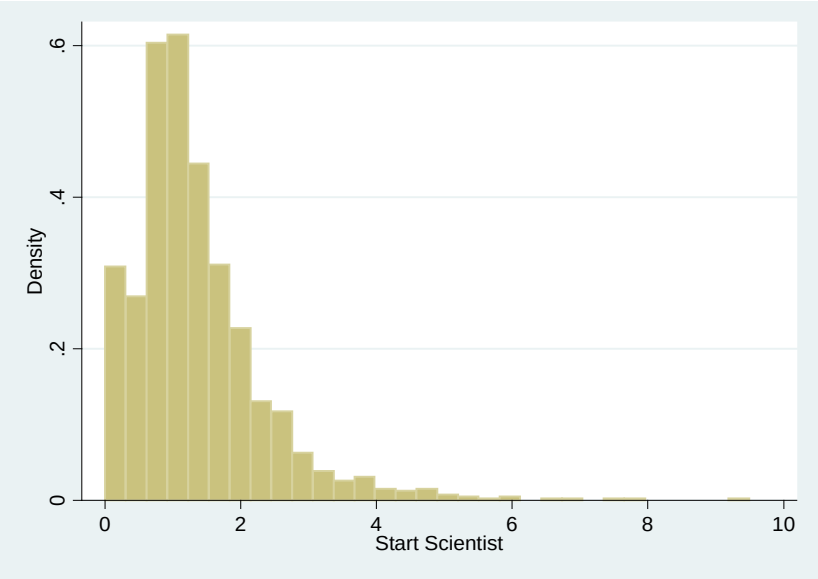
MEASURES: Explanatory variables

- ***RESEARCH EXCELLENCE***

  • For each scientist we compute the average number of citations per year and paper

  • For each paper we computed the average number of citations received per year (given the year of publication of each paper), and then the sum of scores for all the papers of a particular scientist was normalised by his/her total number of publications.

  • Publications refer to all SCI recorded papers published by each single scientist in our study (i.e. total number of publications of each scientists until 2010 included).



DESCRIPTIVE STATISTICS	
Mean	1.34
Median	1.14
Mode	0.00
Min	0.00
Max	9.18

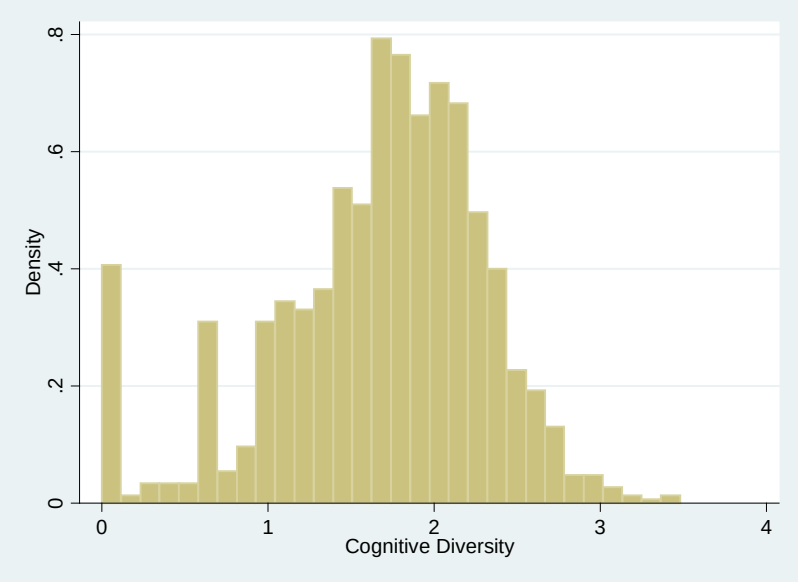
MEASURES: Explanatory variables

▪ *COGNITIVE DIVERSITY*

• This is a measure of diversity based on the range of ISI-SCI subject categories of the articles published by each researcher.

• The measure is built according to Shannon entropy index: the larger the number of subject categories covered by a researcher's publications, and the more even the proportion of publications across the subject categories, the higher the value of the index.

• Shannon Entropy Index: $- \Sigma\, p_i * log\, p_i$, where p_i is the proportion of articles belonging to the *i*th subject category.



DESCRIPTIVE STATISTICS	
Mean	1.68
Median	1.76
Mode	0.00
Min	0.00
Max	3.48

MEASURES: Explanatory variables

- ***COGNITIVE DIVERSITY***

Scientist	Score of Cog. Divers.	No. of subject categ.	Extract of scientific categories (number of publications within each scientific category)	No. of publicat.
Case 1	0.00	1	Astronomy & Astrophysics (26)	26
Case 2	0.21	2	Astronomy & Astrophysics (53) / Multidisciplinary Sciences (2)	55
Case 3	1.06	2	Plant Sciences (8) / Biochemistry & Molecular Biology (6)	14
Case 4	2.05	10	Applied Physics (11) / Materials Science (5) / Chemistry Physical (4) / Spectroscopy (1) / …	25
Case 5	3.48	62	Microbiology (24) / Polymer Science (23) / Biotechnology (25) / Food Science & Technology (30) / Organic Chemistry (16) / …	243

MEASURES: Explanatory and control variables

- ***KNOWLEDGE TRASNFER EXPERIENCE***

  • This measure is build as the total value (in €s) of all contracts (i.e. R&D contracts, consulting, license agreements, …) in which researchers are formally recorded as PIs over the period 1999-2010

  • Since the variable displays a highly skewed distribution, we have transformed this variable logarithmically (i.e. ln (x+1))

  • 57% of scientists did not obtain funding sources from commercial act. over 1999-2010 (according to CSIC administrative records)

- ***CONTROL VARIABLES***

  • ***Socio demographic:***

    • *age, gender (male=1), academic status (professor=1)*

  • ***Motivational features: Expected gains from the interaction with non-academic agents***

    • *To foster research / To expand professional networks / To obtain personal income*

  • ***Scientists' perception of supportive climate for K.T. in their institute*** (Cronbach α=0.92)

  • ***'Controlled' and 'Autonomous' motivation*** *to conducting scientific research*

  • ***Number of articles published*** *(ln transformed)*

  • ***Scientific discipline*** *(8 dummies: "Biology & Biomedicine" is the reference category)*

RESULTS

Tobit estimates. Dependent variable: *PRO-SOCIAL RESEARCH behaviour*

	MODEL 1
Variables	β-estimates
RESEARCH EXCELLENCE	
COGNITIVE DIVERSITY	
K.T. EXPERIENCE	
RESEARCH EXCELLENCE ^{2}	
COGNITIVE DIVERSITY ^{2}	
ADVANCING RESEARCH	0.217 ***
EXPANDING NETWORK	0.317 ***
PERSONAL INCOME	-0.035
CLMIATE	0.020 *
GENDER (MALE)	0.086 *
PROFESSOR	0.019
AGE	0.009 ***
CONTROL. MOTIVATION	0.059 *
AUTONOM. MOTIVATION	-0.081 *
LN N. PUBLICATIONS	-0.005
INTERCEPT	1.366 ***
SCIENTIFIC FIELD DUMMIES	Included
Pseudo R^2 (McKelvey & Zavoina)	0.16
N. Observations	1195

* $p < 0.10$; ** $p < 0.05$: *** $p < 0.01$

Tobit estimates. Dependent variable: *PRO-SOCIAL RESEARCH behaviour*

Variables	MODEL 1 β-estimates	MODEL 2 β - estimates	
RESEARCH EXCELLENCE		-0.042 *	*H1a*
COGNITIVE DIVERSITY		0.092 **	*H3a*
K.T. EXPERIENCE		0.030 ***	
RESEARCH EXCELLENCE ^{2}			
COGNITIVE DIVERSITY ^{2}			
ADVANCING RESEARCH	0.217 ***	0.209 ***	
EXPANDING NETWORK	0.317 ***	0.301 ***	
PERSONAL INCOME	-0.035	-0.022	
CLMIATE	0.020 *	0.001	
GENDER (MALE)	0.086 *	0.066	
PROFESSOR	0.019	-0.004	
AGE	0.009 ***	0.004	
CONTROL. MOTIVATION	0.059 *	0.052	
AUTONOM. MOTIVATION	-0.081 *	-0.072	
LN N. PUBLICATIONS	-0.005	-0.047 *	
INTERCEPT	1.366 ***	1.847 ***	
SCIENTIFIC FIELD DUMMIES	Included	Included	
Pseudo R^2 (McKelvey & Zavoina)	0.16	0.20	
N. Observations	1195	1195	

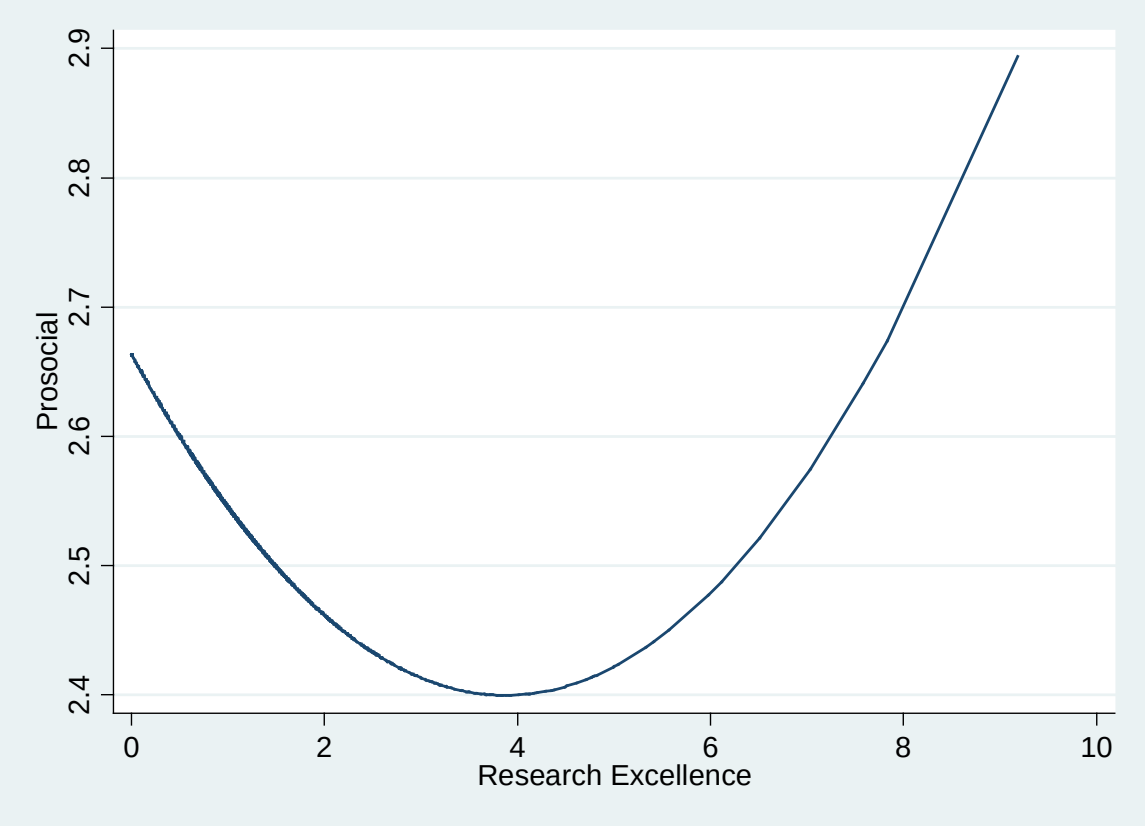
* $p < 0.10$; ** $p < 0.05$: *** $p < 0.01$

Tobit estimates. Dependent variable: *PRO-SOCIAL RESEARCH behaviour*

Variables	MODEL 1 β-estimates	MODEL 2 β - estimates	MODEL 3 β - estimates	
RESEARCH EXCELLENCE		-0.042 *	-0.089 ***	*H1b*
COGNITIVE DIVERSITY		0.092 **	0.092 ***	
K.T. EXPERIENCE		0.030 ***	0.029 ***	
RESEARCH EXCELLENCE ^{2}			0.018 *	*H1b*
COGNITIVE DIVERSITY ^{2}				
ADVANCING RESEARCH	0.217 ***	0.209 ***	0.212 ***	
EXPANDING NETWORK	0.317 ***	0.301 ***	0.298 ***	
PERSONAL INCOME	-0.035	-0.022	-0.023	
CLMIATE	0.020 *	0.001	0.009	
GENDER (MALE)	0.086 *	0.066	0.066	
PROFESSOR	0.019	-0.004	0.001	
AGE	0.009 ***	0.004	0.003	
CONTROL. MOTIVATION	0.059 *	0.052	0.053 *	
AUTONOM. MOTIVATION	-0.081 *	-0.072	-0.070	
LN N. PUBLICATIONS	-0.005	-0.047 *	-0.034	
INTERCEPT	1.366 ***	1.847 ***	1.817 ***	
SCIENTIFIC FIELD DUMMIES	Included	Included	Included	
Pseudo R^2 (McKelvey & Zavoina)	0.16	0.20	0.21	
N. Observations	1195	1195	1195	

* $p < 0.10$; ** $p < 0.05$: *** $p < 0.01$

Relationship: Pro-Social – Research Excellence

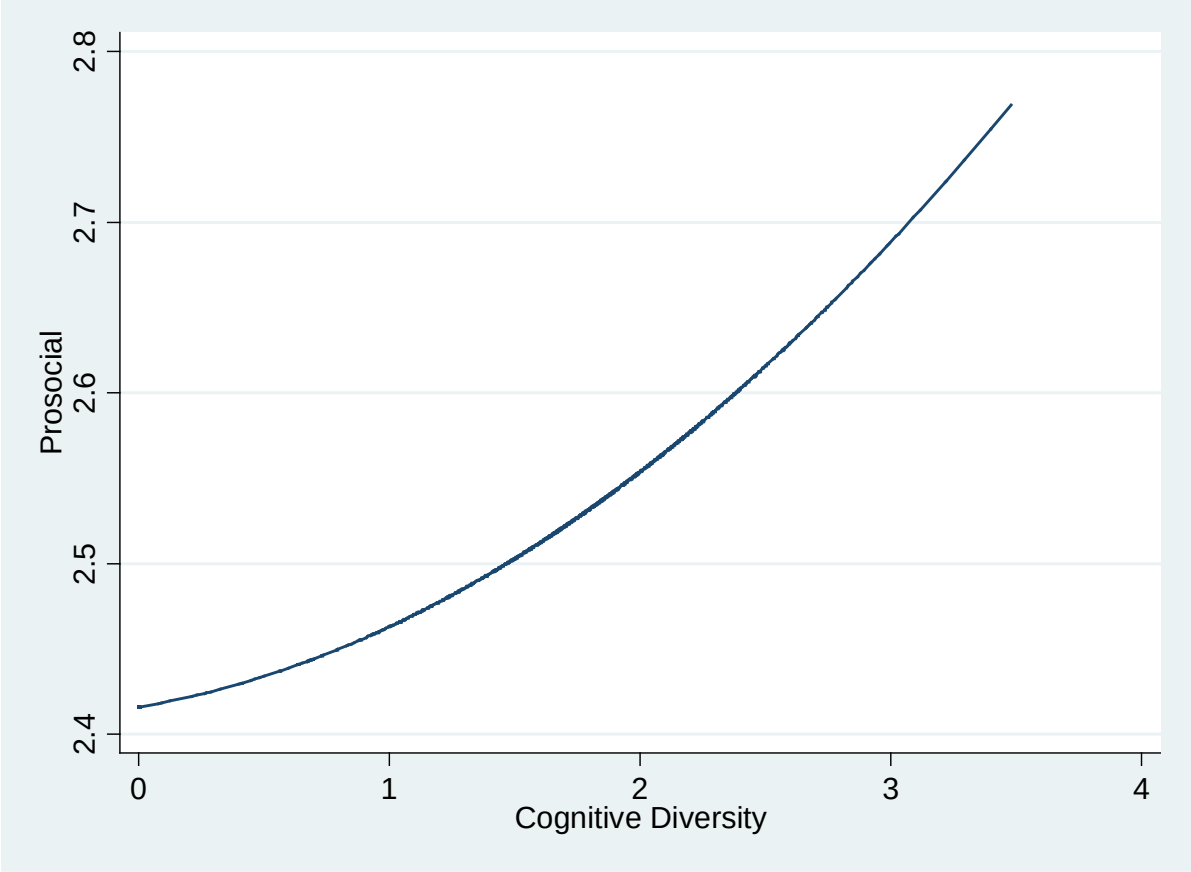


Tobit estimates. Dependent variable: *PRO-SOCIAL RESEARCH behaviour*

Variables	MODEL 1 β-estimates	MODEL 2 β - estimates	MODEL 3 β - estimates	MODEL 4 β - estimates	
RESEARCH EXCELLENCE		-0.042 *	-0.089 ***	-0.042 *	
COGNITIVE DIVERSITY		0.092 **	0.092 ***	0.099 **	*H3b*
K.T. EXPERIENCE		0.030 ***	0.029 ***	0.030 ***	
RESEARCH EXCELLENCE ^{2}			0.018 *		
COGNITIVE DIVERSITY ^{2}				0.021	*H3b*
ADVANCING RESEARCH	0.217 ***	0.209 ***	0.212 ***	0.207 ***	
EXPANDING NETWORK	0.317 ***	0.301 ***	0.298 ***	0.302 ***	
PERSONAL INCOME	-0.035	-0.022	-0.023	-0.021	
CLMIATE	0.020 *	0.001	0.009	0.009	
GENDER (MALE)	0.086 *	0.066	0.066	0.067	
PROFESSOR	0.019	-0.004	0.001	-0.006	
AGE	0.009 ***	0.004	0.003	0.002	
CONTROL. MOTIVATION	0.059 *	0.052	0.053 *	0.050	
AUTONOM. MOTIVATION	-0.081 *	-0.072	-0.070	-0.069	
LN N. PUBLICATIONS	-0.005	-0.047 *	-0.034	-0.045 *	
INTERCEPT	1.366 ***	1.847 ***	1.817 ***	1.829 ***	
SCIENTIFIC FIELD DUMMIES	Included	Included	Included	Included	
Pseudo R^2 (McKelvey & Zavoina)	0.16	0.20	0.21	0.20	
N. Observations	1195	1195	1195	1195	

* $p < 0.10$; ** $p < 0.05$: *** $p < 0.01$

Relationship: Pro-Social – Cognitive Diversity



Tobit estimates. Dependent variable: *PROSOCIAL RESEARCH behaviour*

Variables	MODEL 1 β-estimates	MODEL 2 β - estimates	MODEL 3 β - estimates	
RESEARCH EXCELLENCE		-0.042 *	-0.042 *	
COGNITIVE DIVERSITY		0.092 **	0.092 **	
K.T. EXPERIENCE		0.030 ***	0.030 ***	
*K.T.EXPERIENCE * RESEARCH EXCELLENCE*			0.001	*H2*
*K.T. EXPERIENCE * COGNITIVE DIVERSITY*				
ADVANCING RESEARCH	0.217 ***	0.209 ***	0.209 ***	
EXPANDING NETWORK	0.317 ***	0.301 ***	0.301 ***	
PERSONAL INCOME	-0.035	-0.022	-0.022	
CLMIATE	0.020 *	0.001	0.009	
GENDER (MALE)	0.086 *	0.066	0.056	
PROFESSOR	0.019	-0.004	-0.004	
AGE	0.009 ***	0.004	0.006	
CONTROL. MOTIVATION	0.059 *	0.052	0.052	
AUTONOM. MOTIVATION	-0.081 *	-0.072	-0.072	
LN N. PUBLICATIONS	-0.005	-0.047 *	-0.047 *	
INTERCEPT	1.366 ***	1.847 ***	1.847 ***	
SCIENTIFIC FIELD DUMMIES	Included	Included	Included	
Pseudo R^2 (McKelvey & Zavoina)	0.16	0.20	0.20	
N. Observations	1195	1195	1195	

* $p < 0.10$; ** $p < 0.05$: *** $p < 0.01$

Tobit estimates. Dependent variable: *PROSOCIAL RESEARCH behaviour*

Variables	MODEL 1 β-estimates	MODEL 2 β - estimates	MODEL 3 β - estimates	MODEL 4 β - estimates
RESEARCH EXCELLENCE		-0.042 *	-0.042 *	-0.041 *
COGNITIVE DIVERSITY		0.092 **	0.092 **	0.086 **
K.T. EXPERIENCE		0.030 ***	0.030 ***	0.031 ***
*K.T.EXPERIENCE * RESEARCH EXCELLENCE*			0.001	
*K.T. EXPERIENCE * COGNITIVE DIVERSITY*				-0.012 **
ADVANCING RESEARCH	0.217 ***	0.209 ***	0.209 ***	0.213 ***
EXPANDING NETWORK	0.317 ***	0.301 ***	0.301 ***	0.294 ***
PERSONAL INCOME	-0.035	-0.022	-0.022	-0.022
CLMIATE	0.020 *	0.001	0.009	0.008
GENDER (MALE)	0.086 *	0.066	0.056	0.067
PROFESSOR	0.019	-0.004	-0.004	-0.001
AGE	0.009 ***	0.004	0.006	0.004
CONTROL. MOTIVATION	0.059 *	0.052	0.052	0.052
AUTONOM. MOTIVATION	-0.081 *	-0.072	-0.072	-0.069
LN N. PUBLICATIONS	-0.005	-0.047 *	-0.047 *	-0.045 *
INTERCEPT	1.366 ***	1.847 ***	1.847 ***	1.837 ***
SCIENTIFIC FIELD DUMMIES	Included	Included	Included	Included
Pseudo R^2 (McKelvey & Zavoina)	0.16	0.20	0.20	0.21
N. Observations	1195	1195	1195	1195

H4

* $p < 0.10$; ** $p < 0.05$: *** $p < 0.01$

PRELIMINARY CONCLUSIONS

- Both *research excellence* and *cognitive breadth* play important roles in explaining Pro-Social research behaviour

  – *Excellence in research* shows a positive association with Pro-Social research behaviour, but only beyond a certain threshold of excellence (measured by citation impact):

    - at intermediate levels of research excellence, scientists seem to be comparatively reluctant to embrace a Pro-Social research behaviour

    - inclusion of KT performance indicators in the set of merits for academic promotion and peer recognition, to attenuate the tensions between academic norms and involvement in commercial activities

  – *Cognitive diversity* has a positive impact in shaping a Pro-Social research behaviour.

    - Scientists who are more capable to integrate multiple bodies of knowledge in their research activities and/or display a frequent transit across scientific fields, exhibit a more favourable attitude towards K.T.

    - From a policy perspective: this is an important argument to stimulate more interdisciplinary research tracks in scientists' academic profiles

PRELIMINARY CONCLUSIONS

- Regarding interactions:

– We find that past experience in K.T. activities is a very strong predictor of Pro-Social research behaviour (and the formation of favourable attitudes/mindsets towards K.T. in research activities).

– However,

- Cognitive Diversity skills act as a substitute for experience: the impact of Cognitive Diversity on Pro-Social research is stronger for scientists who exhibit little (or no) previous K.T. experience.
- This reinforces the importance of Cognitive Diversity, as this type of skills may compensate for the absence of prior experience in K.T. activities among scientists:
  - Encouraging multidisciplinary research tracks could be powerful means to enhance Pro-Social research and to contribute to the formation of favourable attitudes and conducts to engage in knowledge transfer activities
  - particularly within an environment ruled by norms that are often in conflict with K.T. involvement.

Literature background (3)

What type of *skills* are more conducive to pro-social research behaviour among scientists?

- *Experience*: *habitual entrepreneurs and mastering enacting skills in K.T.*

Scientists who have engaged in knowledge transfer activities in the past are likely to be more willing and able to conduct pro-social research

– prior experience in entrepreneurship might help individuals develop specific skills to become "habitual entrepreneurs" (Hoye & Prices, 2009; Shane & Khurana, 2003)

– scientists with successful experience in KT may become more aware of the commercialization potential of their research results (Goethner, et al., 2012; Landry et al., 2006)

- *However, our contention is that Pro-Social research is likely to be a behavioural antecedent of involvement in knowledge and technology transfer*

– Thus, the question is: what type of skills help engage in pro-social research among those individuals who have *no (or little)* previous experience in knowledge transfer?

– We consider *Research Excellence* and *Cognitive diversity* as potential substitutes for *Experience*.

Proportion of scientists with High / Low *Pro-Social* scores, by field of science

Scientific fields	HIGH PRO-SOCIAL (highest 33%)	LOW PRO-SOCIAL (lowest 33%)	N. Obs.
Food Science & Technology	54 (48%)	17 (15%)	113
Social Science & Humanities	30 (43%)	22 (32%)	69
Agriculture Science & Technology	73 (39%)	41 (22%)	185
Physics Science & Technology	58 (38%)	53 (35%)	153
Technology for New **Materials**	51 (32%)	56 (35%)	158
Chemistry Science & Technology	55 (32%)	54 (31%)	173
Natural Resources	48 (26%)	66 (36%)	182
Biology & Biomedicine	31 (17%)	93 (50%)	186
Total	33%	33%	1219

DESCRIPTIVE STATISTICS

	MEAN	MEDIAN	S.D.	MIN.	MAX.	N.OBS.
PRO-SOCIAL RESEARCH	2.688	2.600	0.656	1.000	4.000	1196
STAR SCIENTIST	1.345	1.142	1.003	0.000	9.183	1249
COGNITIVE DIVERSITY	1.676	1.764	0.644	0.000	3.482	1249
K.T. EXPERIENCE	4.736	0.000	5.588	0.000	15.852	1249
ADVANCING RESEARCH	1.108	1.000	0.522	0.000	2.000	1237
EXPANDING NETWORK	0.859	1.000	0.509	0.000	2.000	1235
PERSONAL INCOME	0.261	0.000	0.552	0.000	2.000	1239
CLMIATE	2.131	2.000	1.782	0.000	4.000	1249
GENDER (MALE)	0.649	1.000	0.477	0.000	1.000	1249
AGE	49.826	49.000	8.245	31.000	70.000	1249
PROFESSOR	0.230	0.000	0.421	0.000	1.000	1249
N. PUBLICATIONS (Not LN)	32.609	25.000	32.032	1.000	286.000	1249
CONTROLLED MOTIVATION	2.843	3.000	0.712	1.000	4.000	1239
AUTONOMOUS MOTIVATION	3.642	4.000	0.475	1.667	4.000	1248
BIOLOGY & BIOMED.	0.154	0.000	0.361	0.000	1.000	1249
FOOD TECHNOLOGY	0.093	0.000	0.290	0.000	1.000	1249
MATERIALS TECHNOL.OGY	0.129	0.000	0.336	0.000	1.000	1249
PHYSICS Sc. &. T.	0.126	0.000	0.332	0.000	1.000	1249
CHEMISTRY Sc. & T.	0.140	0.000	0.347	0.000	1.000	1249
AGRICULTURE Sc. & T.	0.151	0.000	0.359	0.000	1.000	1249
SOCIAL SC. & HUMANITIES	0.058	0.000	0.235	0.000	1.000	1249
NATURAL RESOURCES	0.140	0.000	0.355	0.000	1.000	1249